Chapter One

The National Aeronautics and Space Administration in Transition

The Administration's five-year plan for the National Aeronautics and Space Administration (NASA) requires that the agency carry out its program with a nearly flat budget. This prospect marks a significant change for NASA: since the mid-1980s, the agency has planned its program with the expectation of continuous increases in funding. NASA has developed a two-pronged strategy to maintain productivity in the face of its constrained budget outlook. First, the agency is making marginal adjustments to the content of its program by stretching out, scaling down, and even canceling some projects. Second, NASA is seeking to improve the way it does business to get more in return for the money that it spends. This study evaluates NASA's strategy and an alternative one that would radically change the agency's program by emphasizing one or another of the broad objectives that NASA has historically pursued.

NASA bears major responsibility for the nation's space and aeronautics activities. Its most visible efforts are the flights of the piloted space shuttle. It also develops, launches, and operates unpiloted spacecraft whose purpose is to increase knowledge about the Earth, the solar system, and the universe. To accomplish those missions, NASA conducts research and develops supporting technologies for piloted and unpiloted missions alike. The agency also plays a key role in supporting research and providing facilities to meet the nation's civil and military aviation needs.

In 1994, NASA was permitted over 24,000 full-time-equivalent workyears (figured in time spent by federal workers) to accomplish its objectives. Personnel were located at the agency's Washington headquarters and nine major installations, or centers (for example, the Johnson Space Center in Houston). NASA's federal employees bear responsibility for all aspects of the agency's activity, but private industry executes most of NASA's program. The agency's procurements from industry typically total more than 90 percent of its annual spending.

What Is at Stake?

NASA's total funding for 1993 was $14.3 billion, which constituted less than 1 percent of all federal spending. The agency's budget for research and development (R&D), however, accounted for 5 percent of total national investment in R&D, over 10 percent of federal funding for R&D, and almost 25 percent of nondefense federal funding for R&D.[1] NASA applies these resources to objectives in three major areas: the piloted exploration of space, scientific research on space-related topics, and the development of space and aeronautical technologies for carrying out future public missions in space and for serving the technological needs of private industry. NASA's supporters contend that accomplishment in these areas improves the nation's self-image, enhances its international prestige, furthers certain foreign policy objectives, creates new scientific knowledge, quickens the pace of technological change, and contributes to economic productivity in

1. For total federal and NASA research and development for 1993, see *Budget of the United States Government, Fiscal Year 1994*, pp. 44-45; for total national R&D spending, see National Science Foundation, "U.S. Expenditures on R&D Expected to Increase in 1993," *SRS Data Brief*, September 24, 1993.

the aerospace industries and perhaps, indirectly, in the larger economy. Ultimately, it is these contributions that are at stake when decisions are made about NASA's program or budget or when questions arise about how well the agency manages its resources.

The Agency's Objectives and Their Value

Although the objectives of the NASA program are easily listed, measuring progress toward those goals and valuing that progress in dollar terms have proved to be extremely difficult.[2] The lack of objective evaluation leaves substantial room for equally supportable but very different opinions about the appropriate mix of activities in NASA's program or the potential benefits from increasing the efficiency of the agency. For example, advocates for continued emphasis on piloted spaceflight place a high value on such activities and attribute to them both past and potential future successes in U.S. foreign policy. Advocates for the agency's space science efforts argue that most of the important benefits that NASA has produced in its 37-year history have been generated by the less than 20 percent of its total budget devoted to scientific enterprises. No objective measure exists to compare these contrasting visions of what NASA has accomplished and the value of its current activities.

This analysis does not solve the problem of how to value NASA's activities. Instead, it emphasizes two points. The first is that the balance that NASA's current program strikes among piloted exploration, space science missions, and technology development is only one of several possible choices. As funds become scarcer, the agency may either rearrange its priorities under the current level of funding or focus on a more limited set of objectives (and accomplish them for less than it now spends).

The second point is that a scaled-down version of NASA's current program plan (the first part of its strategy for dealing with its constrained means) may not be the best use of the agency's resources. Although the benefits of NASA's activities cannot be quantified, common sense suggests that underfunded or poorly planned projects will not accomplish the objectives that ultimately produce the benefits associated with NASA's program. A major question arises about whether the current program can be rationally downsized and avoid the trap of functioning as a level-of-effort enterprise--one that is mired in stretched-out, overbudget projects that do not meet their objectives and fail to deliver their ultimate benefits.

NASA and the Economy

How NASA affects the U.S. economy is likely to consume a large part of any debate about the agency's program. The problems involved in assessing the direct benefits that NASA provides have led some advocates of continued increases in spending for the agency to claim that the indirect influence of NASA's program on the economy is sufficient to justify its cost. The more general issue of what the federal government--and taxpayers--are receiving from their R&D investments has also focused attention on the economic consequences of NASA's spending.

The balance of the evidence does not support higher levels of funding for NASA as a means to increase economywide productivity. In the short term, NASA's spending affects the economy in the same way that other government spending does--and is properly viewed as a cost rather than a benefit of the program (see Box 1). Over the longer term, NASA's contribution to the economy does not appear to be large when measured by the most objective standard. Studies that employ other approaches requiring large measures of judgment by the analyst and examine NASA's contribution within particular markets can be used to bolster the argument that past spending by NASA has led to increased productivity. But for the most part, economists have rejected the argument that would justify NASA's program based on its contribution to the economy.

2. A report by the Office of Technology Assessment, *Federally Funded Research: Decisions for a Decade* (May 1991), discusses the general issues of measuring and valuing the output of R&D agencies. The difficulties in measuring and valuing NASA's output are not unique; similar problems exist in measuring the value of most federally supported R&D efforts.

Box 1.
Short-Term Economic Effects of Spending for the National Aeronautics and Space Administration

NASA's spending does not have a uniquely large short-term effect on the U.S. economy. All federal spending for goods and services tends to stimulate the economy temporarily, increasing growth and employment for a short time (provided that the economy is not already at full employment). Such spending also tends to increase inflation and interest rates.

Under certain conditions, NASA's expenditures could have a slightly larger or smaller short-run effect on the growth of the economy and on employment compared with federal spending overall. For example, if an unusually large proportion of NASA's spending was directed toward industrial sectors or regions of the country that were experiencing much higher unemployment than the nation as a whole, the effects of the spending would be slightly larger, although still temporary. If spending for NASA was concentrated in industries that had a high value added per worker, the effect on employment would be slightly smaller than federal spending overall. On balance, nothing suggests that unique aspects of NASA's spending cause it to affect the economy differently from other types of federal spending for goods and services.

Production Function Studies. A production function is a mathematical formulation that relates the value of output to the value of inputs. Compared with other approaches (for example, cost-benefit analyses or case studies), production function studies require the analyst to make the fewest assumptions and subjective judgments.[3] The private firm Chase Econometrics Associates prepared two such studies under contract to NASA; the General Accounting Office (GAO) conducted another that evaluated the first Chase study. All of the studies illustrate the issues associated with attempting to discover NASA's contribution to private productivity.[4]

The first Chase study found a substantial contribution by NASA to productivity--indeed, one large enough to explain all of the productivity growth in the U.S. economy over the 1965-1974 period. (The equivalent return on NASA's research and development spending would have been 43 percent.) The GAO critique showed that small changes in the period covered in the estimate or in assumptions about capacity utilization or labor quality reduced the estimate of NASA's contribution to a level indistinguishable from zero.[5] The second Chase report confirmed the GAO finding.[6]

3. At the economywide level, many studies have found a strong relationship between spending for R&D and productivity. But when the contributions to economic growth of private R&D and public R&D are evaluated separately, private spending remains a strong positive factor, and public investment in R&D is not correlated with growth in productivity. See, for example, Frank Lichtenberg, "R&D Investment and International Productivity Difference," Working Paper 4161 (National Bureau of Economic Research, Cambridge, Mass., September 1992), p. 24. The author notes that from the mid-1960s through the late 1980s there was a "*negative*, large, and highly significant" relation between government-funded R&D and output.

4. Michael K. Evans, "The Economic Impact of NASA R&D Spending" (Chase Econometrics Associates, Inc., Washington, D.C., April 1976); General Accounting Office, *NASA Report May Overstate the Economic Benefits of Research and Development Spending* (October 1977); and David M. Cross, "The Economic Impact of NASA R&D Spending: An Update" (Chase Econometrics Associates, Inc., Washington, D.C., March 1980).

5. One of the most frequently quoted estimates of NASA's contribution to economic growth--for every $1 of NASA R&D spending, $9 will be returned to the economy over a roughly 20-year period --relies on a production function approach. (See Midwest Research Institute, *Economic Impact and Technological Progress of NASA Research and Development Expenditures*, vol. 2, *Economic Impacts of NASA R&D Expenditures*, Kansas City, Mo., Midwest Research Institute, 1988, pp. II-2 through II-3.) The study by the Midwest Research Institute makes two debatable assumptions that are unsupported by other research: that NASA's R&D is as productive as the average of all publicly and privately funded R&D, and that NASA's R&D investment falls into the same category of federal R&D as health and agriculture (for which positive returns have been found) rather than into the category with "purely military projects" (for which positive results have not been found). In contrast to the latter assumption, most analysts argue that NASA's activities are similar to those on the defense side of government, exhibiting the same mission orientation and relying on the same contractor base.

6. Another study by the Department of Labor's Bureau of Labor Statistics (*Impact of Government and Private R&D Spending on Factor Productivity in Space Manufacturing*, July 1980) also found no measurable relation between R&D spending by NASA and changes in productivity in industries that are directly affected by NASA procurement.

The conclusion of such studies--that NASA's R&D spending has not had a significant effect on national productivity--is neither surprising nor indicative of a waste of resources. The case can be made that these results fail to capture a positive effect that is actually occurring.[7] The benefits of new products that come from R&D activities are more difficult to assess than the reductions in costs permitted by innovations in production processes. To the extent that all federal R&D and NASA efforts are biased toward innovation in products rather than processes, the contributions from those efforts could be understated.

Other Studies. Cost-benefit analyses (many of them supported by NASA) have been undertaken to determine the effect of the agency's programs on consumers and producers.[8] Studies of this type have characteristically produced large ratios of benefits to costs or large estimates of the benefits from specific innovations generated by NASA funding. These studies have considered innovations that were spun off from NASA's spaceflight and science programs as well as those supported by its general research and technology programs.

Studies of this kind constitute a microeconomic approach that requires the analyst to make numerous assumptions about where the credit for an innovation lies, the period over which benefits should be assessed, conditions of supply and demand in directly affected and related markets, and the possibility that in the absence of the innovation being evaluated an alternative might have been devised. Consequently, cost-benefit studies of past NASA efforts include a large measure of subjective judgment. Nevertheless, the studies demonstrate that placing the contribution of NASA's R&D at zero, a result that could be implied by the production function studies, is probably as mistaken as attributing large parts of past productivity growth in the national economy to NASA's program.

Case studies of NASA's role in influencing the development of three industries--aviation, satellite communications, and materials processing in space--also provide data about the economic effects of NASA's programs. The agency's historical role in the aviation industry is generally viewed as positive;[9] its support of the communications satellite industry is usually but not always assessed as a positive contribution.[10] NASA's more recent attempts to create new industries requiring piloted spaceflight have been failures to date.[11]

A 1992 study employing a historical approach and a large measure of subjective judgment reviewed the concept of the "spin-off"--a product or process developed by NASA for its purposes that finds its way into the larger economy and leads to increased productivity.[12] The spin-off occupies a central place in the mythology of NASA's relation to the private economy and, accordingly, in the argument that secondary economic benefits might justify spending for NASA. The study's critique of spin-offs as an organizing principle for technology

7. Henry R. Hertzfeld, "Measuring the Returns to Space Research and Development," in Joel Greenberg and Henry Hertzfeld, eds., *Space Economics* (Washington, D.C.: American Institute of Aeronautics and Astronautics, 1992), pp. 153-155.

8. See, for example, Mathematica, Inc., *Quantifying the Benefits to the National Economy from Secondary Applications of NASA Technology* (National Aeronautics and Space Administration, March 1976). The study found that NASA's role in four innovations (a computer program used to analyze large structures, integrated circuits, insulation for supercooled materials, and the gas turbine engine--an effort begun by NASA's predecessor in the 1940s) produced $7 billion (in 1974 dollars) in net benefits.

9. David Mowery and Nathan Rosenberg, *Technology and Economic Growth* (New York: Cambridge University Press, 1989), pp. 181-184; and George Eberstadt, "Government Support of the Large Commercial Aircraft Industries of Japan, Europe, and the United States" (Office of Technology Assessment, May 1991), pp. 63-87.

10. Recent studies of satellite communications and NASA's role in creating that industry do not agree fully about the significance of NASA's activities. Linda Cohen and Roger Noll, "The Applications Technology Satellite Program," in Linda Cohen and Roger Noll, eds., *The Technology Pork Barrel* (Washington, D.C.: Brookings Institution, 1991), pp. 149-178, offer a generally favorable appraisal of NASA's role in the private satellite communications industry, citing the agency's development of satellite technology and its role in providing launch services. A contrasting view is offered in Peter Cunniffe, "Misreading History: Government Intervention in the Development of Commercial Communications Satellites," Report 24 (Program in Science and Technology for International Security, Massachusetts Institute of Technology, Cambridge, Mass., May 1991). The author accepts the importance of NASA's role in providing launch services but finds that most of the significant technical innovations in the industry were privately financed and developed.

11. See Chapter 4 in Congressional Budget Office, *Encouraging Private Investment in Space Activities* (February 1991).

12. John Alic and others, *Beyond Spinoff: Military and Commercial Technologies in a Changing World* (Boston: Harvard Business School Press, 1992).

policy noted that the technology and institutional arrangements necessary for success in the missions of federal agencies were diverging from the characteristics necessary for success in private markets. It concluded that "grandiose projects patterned on the Apollo moon landing or the Strategic Defense Initiative will be increasingly irrelevant to world technological competition."[13] The analysis suggests that, even if spin-offs from NASA's program were important in the past, they are unlikely to be as important in the future. The production systems that NASA requires and those that serve the private market follow different paths.

The Structure of NASA's Program and Budget

In 1994, NASA received $14.6 billion in budget authority, which it allocated as shown in Table 1. Funding for the space shuttle system, including both operations and continuing investment, was the largest single item at $3.8 billion--over 25 percent of NASA's total appropriation. Funding for the space station at $1.9 billion was the next largest single item and accounted for 13 percent of the agency's budget. The space science and applications program, which supports the robotic spacecraft that NASA uses to gather information about the Earth and space, received $3.3 billion in 1994. That funding was concentrated in three areas: physics and astronomy ($1.1 billion), planetary exploration ($650 million), and Earth science ($1.1 billion). NASA allocated $1.4 billion to efforts to advance aeronautics and space technology, with more than 70 percent of the total going to aeronautics. The bulk of NASA's remaining funds were divided among the accounts that pay federal employees and that support the construction of facilities.

Funding Trends During the 1980s

NASA's current funding is about twice the $7.2 billion granted the agency in 1984 but only a small

13. Ibid., pp. 12-13.

Table 1.
Initial Operating Plan for the National Aeronautics and Space Administration, 1994 (In millions of dollars of budget authority)

Category of Spending	Amount
Research and Development	
Space station	1,946
Space transportation capability	663
Space science and applications	
Physics and astronomy	1,068
Planetary exploration	654
Life sciences	188
Microgravity	177
Earth science (Mission to Planet Earth)	1,068
Other[a]	162
Subtotal	3,307
Advanced concepts and technology[b]	433
Aeronautical research and technology	1,007
Transatmospheric research and technology	20
Safety, reliability, and quality assurance	34
Academic programs	86
Tracking and data advanced systems	24
Total	7,529
Space Flight, Control, and Data Communications	
Shuttle production and operations capability	1,035
Shuttle operations	2,744
Space and ground tracking systems	761
Launch services	313
Total	4,853
Construction of Facilities	518
Research and Program Management	1,636
Inspector General	15
Total, All Categories	14,551

SOURCE: Congressional Budget Office based on data from National Aeronautics and Space Administration, "Initial Operating Plan for 1994" (1993).

NOTE: Numbers may not add to totals because of rounding.

a. Includes some spacelab costs for life sciences and microgravity experiments and $50 million for U.S.-Russian cooperative activities.

b. Formerly Space Research and Technology, and Commercial Programs.

increase compared with NASA's 1991 funding level of $13.9 billion. Between 1984 and 1991, the NASA budget increased at an average rate of 9.7 percent annually. Between 1991 and 1994, annual average growth in the agency's budget fell to 1.5 percent.

Traditionally, NASA presents its budget to the Congress as the sum of four major appropriations (see Table 2). (NASA's 1995 budget request includes a change in its appropriations from the traditional accounts shown in Table 2 to a new scheme discussed in Box 2.) The Research and Development category supports development of aeronautics and space technology, and development and operation of both piloted and robotic spacecraft--with the major exception of the space shuttle. Spending for the Research and Development component more than tripled over the past decade, increasing its share of the agency's budget from about 30 percent in 1984 to around 50 percent in 1994.

The increase in NASA's research and development spending was driven by the piloted space station program and large-scale robotic space science projects. In 1984, spending for the space station was less than $100 million spread throughout the agency. By 1994, annual funding had reached $1.9 billion. Large robotic space science missions also contributed to the growth in NASA's research and development spending. In the mid-1980s, spending for physics and astronomy projects (the Hubble Space Telescope and the Compton Gamma Ray Observatory) and spacecraft for planetary exploration (the Galileo probe to Jupiter, the Venus Radar Mapper, and the Mars Observer) accounted for the increase. By the late 1980s and early 1990s, those projects were on the downward sloping tail of their budgetary lives, but spending was on the rise in the Earth science area, primarily for the Earth Observation System (EOS). Under the Bush Administration's 1993 budget plan, the space station and the

Table 2.
Budget of the National Aeronautics and Space Administration, 1984-1994
(In millions of dollars of budget authority)

Category	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Research and Development	2,064	2,468	2,619	3,154	3,255	4,238	5,228	6,024	6,827	7,089	7,529
Space Flight, Control, and Data Communications	3,772	3,594	3,666	6,000	3,806	4,452	4,625	5,124	5,385	5,086	4,854
Construction of Facilities	156	158	138	169	178	282	411	498	531	525	518
Research and Program Management	1,256	1,332	1,341	1,452	1,762	1,926	2,023	2,212	1,576	1,615	1,636
Inspector General	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	9	11	14	15	15
Total	7,248	7,552	7,764	10,775	9,001	10,898	12,296	13,869	14,333	14,330	14,551

SOURCE: Congressional Budget Office based on National Aeronautics and Space Administration, *Budget Estimates* (1984-1994).

NOTE: Numbers may not add to totals because of rounding. n.a. = not applicable.

Box 2.
Changes to the National Aeronautics and Space Administration's Appropriations Proposed in the 1995 Budget

The National Aeronautics and Space Administration's (NASA's) budget request for 1995 includes a proposal to redefine NASA's appropriations. Instead of the current division into five appropriations (Research and Development; Space Flight, Control, and Data Communications; Research and Program Management; Construction of Facilities; and the Inspector General), NASA would divide its budget into four categories: Human Space Flight; Science, Aeronautics, and Technology; Mission Support; and the Inspector General. (See the table below, which provides a "bridge" between the current and proposed categories.)

The appropriation structure proposed for 1995 highlights the division of NASA's program between piloted and unpiloted activities in a way that the current structure does not. For 1994, the Research and Development appropriation stood at $7.5 billion, including $1.95 billion for the piloted space station program. The Space Flight, Control, and Data Communications account was funded at $4.9 billion, of which $3.8 billion was allocated to the piloted space shuttle. Under the classifications proposed for 1995, NASA would combine spending for development of the space station with funds for the operation and continued development of the space shuttle. The combined spending would constitute the Human Space Flight appropriation, which in 1994 would have totaled slightly more than $6 billion (with the addition of $300 million for other piloted spaceflight activities). The proposed Science, Aeronautics, and Technology appropriation--which would have been $5.8 billion in 1994, had the new categories been in effect--is essentially the sum of funding for current robotic space science, aeronautics, and technology programs, or the current Research and Development appropriation minus the funding to develop the space station.

The proposed Mission Support appropriation would include all of the current Research and Program Management appropriation (more than $1.6 billion in 1994 for NASA's federal employees). The category would also include funds currently appropriated under the Construction of Facilities accounts and funding for NASA's ground and space tracking system, which is now divided between the Research and Development appropriation and the Space Flight, Control, and Data Communications appropriation.

The budgetary presentations and analysis in this study use the current appropriation categories but translate well into the proposed new structure. This is particularly true of the discussion in Chapter 4 of alternatives to the current NASA program that either dramatically increase or decrease the share of NASA's budget devoted to piloted spaceflight.

Current and Proposed Appropriation Structure for the 1994 Funding for the National Aeronautics and Space Administration (In millions of dollars)

	Proposed Categories			
Current Categories	Human Space Flight	Science, Aeronautics, and Technology	Mission Support	Total
Research and Development	2,435	4,725	369	7,529
Space Flight, Control, and Data Communications	3,601	860	392	4,853
Research and Program Management	n.a.	n.a.	1,636	1,636
Construction of Facilities	33	262	222	518
Total	6,070	5,847	2,619	14,536

SOURCE: Congressional Budget Office based on *Budget of the United States Government, Fiscal Year 1995*, Appendix, p. 821.
NOTES: The Inspector General category is not shown because it remains the same under both structures.
Numbers may not add to totals because of rounding.
n.a. = not applicable.

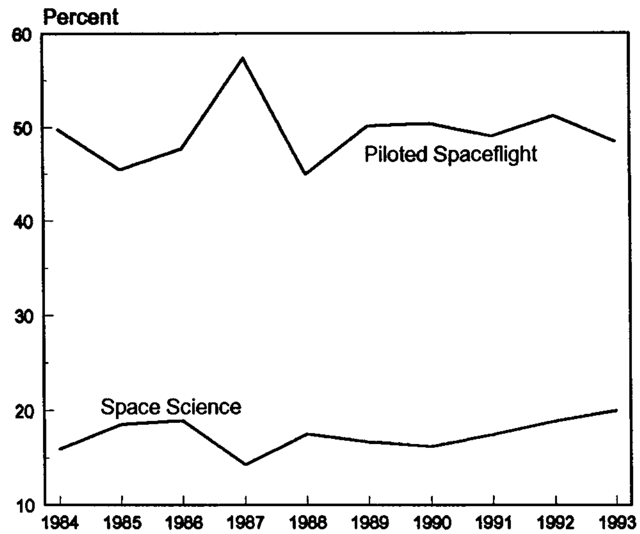
EOS were the two largest civilian R&D projects in the federal budget.[14]

Funding for the space shuttle, traditional unpiloted rockets, and the orbital communications and tracking network is included in the Space Flight, Control, and Data Communications category of accounts. This aggregate has grown more slowly than spending for research and development, as shown by its decline from about 50 percent of the agency's spending in 1984 to around 35 percent in 1994. The spike in funding for spaceflight in 1987 represented the purchase of a replacement orbiter for the Challenger lost in 1986. The other consequences of the Challenger accident for NASA's program do not show up as clearly in budget data. In 1984, the agency received about $3.1 billion to support between 12 and 14 shuttle flights annually. Ten years later, in 1994, the shuttle system was funded at a modestly higher level of $3.8 billion but planned to support only eight flights a year.

The last two major categories of NASA funding are Construction of Facilities and Research and Program Management. The former has more than tripled in size over the past 10 years, but it still accounted for only 4 percent of NASA's spending in 1994. The latter increased from $1.3 billion in 1984 to more than $2.2 billion in 1991 but then fell to $1.6 billion in 1993. (The drop was a consequence of NASA's redefining its accounts to shift about $400 million in funding for maintaining NASA centers and installations from the Research and Program Management accounts to the Research and Development and Space Flight, Control, and Data Communications accounts.)

Several other trends can be identified. The proportion of NASA's budget devoted to piloted spaceflight has remained constant at about 50 percent throughout the decade, as measured by spending for the space station and the space shuttle, development of space transportation capability, and associated space science projects (see Figure 1). The share of space science and applications, a subset of the Research and Development category that is dominated by the development and operation of robotic spacecraft, increased from 16 percent of NASA's budget in 1984 to 20 percent in 1994. If life sciences and microgravity research--activities associated with piloted spaceflight--were excluded, however, the gain in the share of space science would be more moderate. Finally, spending for aeronautics, as measured by program expenditures, has roughly tripled over the past 10 years, and the share of these activities has increased from 4 percent to 7 percent of NASA's budget.

Figure 1.
Budget Shares for Piloted Spaceflight and Space Science, National Aeronautics and Space Administration, 1984-1993 (In percent)



SOURCE: Congressional Budget Office based on data from the National Aeronautics and Space Administration.

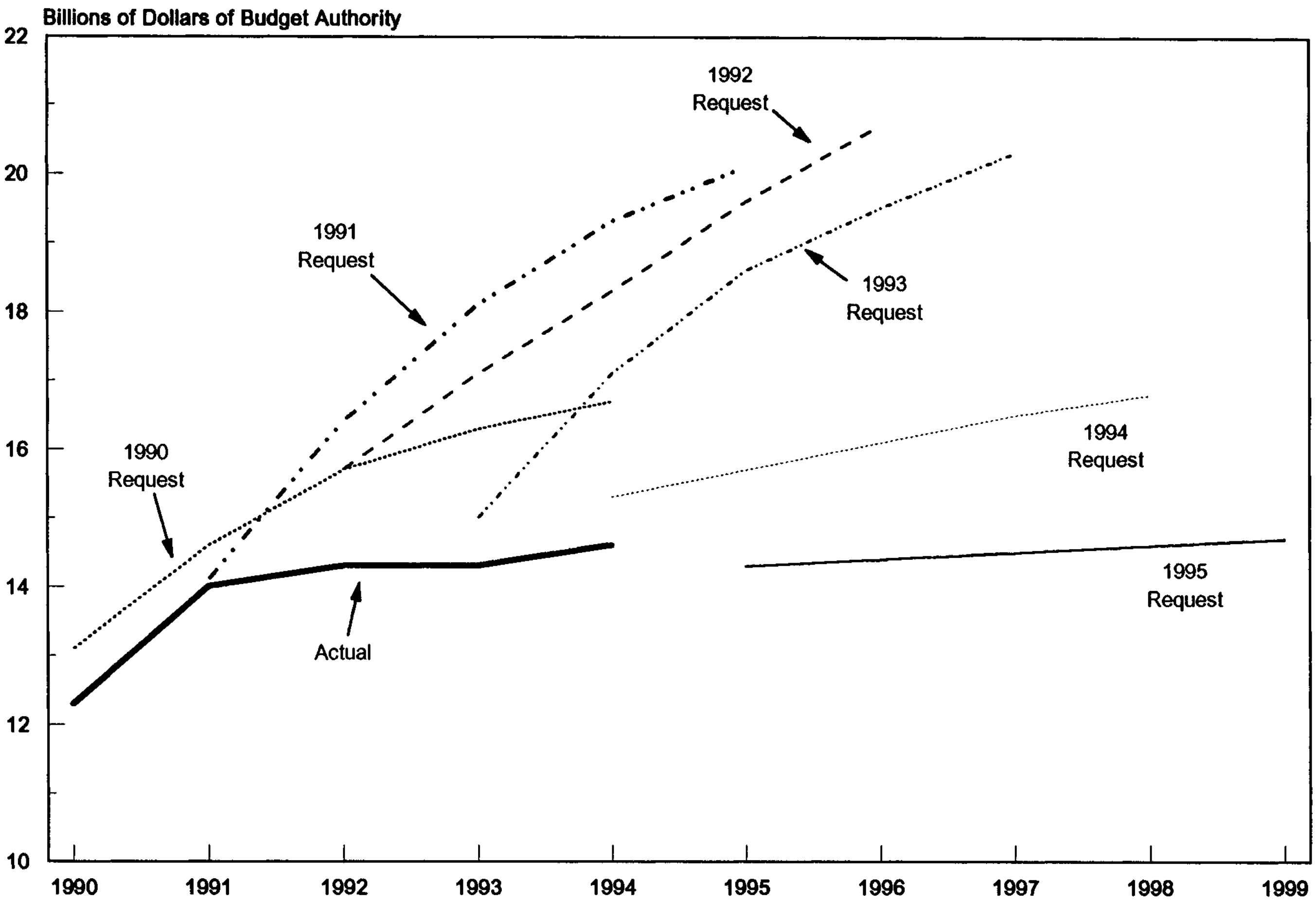
NOTE: Piloted spaceflight includes spending for the space transportation system and the space station only.

The Breaking Bow Wave

What is not apparent in reviewing NASA's funding over the past 10 years is the expectation of future growth that permeated the agency's planning. Since

14. Congressional Budget Office, "Large Nondefense R&D Projects in the Budget: An Update," CBO Staff Memorandum (March 1992), p. 2. For a general approach to measuring the budgetary effects of large projects, see Chapter 2 in Congressional Budget Office, "Large Nondefense R&D Projects in the Budget: 1980-1996," CBO Paper (July 1991).

Figure 2.
Five-Year Budget Requests of the National Aeronautics and Space Administration, 1990-1995
(In billions of dollars of budget authority)



SOURCE: Congressional Budget Office based on *Budget of the United States Government* (various years) and 1993 projections from the NASA Comptroller's Office.

the mid-1980s, NASA's program has required increases in its annual budget above the rate of inflation (see Figure 2).[15] The force driving NASA's future budget requirements upward in the late 1980s was the anticipated cost of first developing and then operating new spacecraft that were to be integrated in a low-Earth-orbit infrastructure. NASA envisioned the infrastructure as including the space shuttle, the space station, tracking and data relay satellites, and several large satellites carrying instruments that looked outward to the stars or back at the Earth. Once in place, this investment was to produce near-term benefits measured in scientific advances, new technologies, and contributions to economic growth. Over the long term, the low-Earth-orbit infrastructure was seen as a stepping-stone for pursuing NASA's long-held goals of a Moon base and a piloted mission to Mars.[16]

The plans for NASA's program outlined in its budget requests for 1990 through 1993 continued to show increasing funding requirements, despite the completion of major parts of the infrastructure. In 1992, GAO testified that NASA's program plan for

15. Congressional Budget Office, *The NASA Program in the 1990s and Beyond* (May 1988), pp. xi-xiv.

16. See Chapter 2 in Howard McCurdy, *The Space Station Decision* (Baltimore, Md.: Johns Hopkins University Press, 1990).

Table 3.
Budget Requests and Appropriations for the National Aeronautics and Space Administration, 1989-1994 (In billions of dollars of budget authority)

	Request	Appro-priation	Differ-ence
1989	11.5	10.9	0.6
1990	13.3	12.3	1.0
1991	15.1	13.9	1.2
1992	15.8	14.3	1.5
1993	15.0	14.3	0.7
1994	15.3	14.6	0.7

SOURCE: Congressional Budget Office based on National Aeronautics and Space Administration, *Budget Estimates* (1989-1994).

1992 through 1997 would require almost $13 billion above the Congressional Budget Office baseline for the agency.[17] This finding was consistent with the conclusion reached two years earlier by a federal advisory committee convened by President Bush. The Advisory Committee on the Future of the U.S. Space Program, better known as the Augustine Committee, found that NASA was over-committed in terms of the scope of its program and would require annual increases of 10 percent above the rate of inflation to realize all of its objectives.[18] As the Clinton presidency began, NASA's budget still required strong growth because the cost of operating current projects remained high and the cost of projects in development continued to increase.

NASA's program plan has attracted the attention of critics in part because of the recent focus on the nation's budget deficit. Concerns about the cost of the NASA program grew after 1990 and the tightening of all domestic discretionary spending required by the Budget Enforcement Act. When the caps in the act began to restrain spending, the Congress significantly lowered NASA's budget from the amounts requested by the President in 1992 and 1993 (see Table 3). For 1994, the Congress again appropriated less than the President requested, despite the Administration's proposal to slow the growth in NASA's five-year program plan by $16 billion compared with the plan included in President Bush's last budget (see Table 4).

Further reductions could be in the offing. The Omnibus Budget Reconciliation Act of 1993 contains a series of caps on appropriations for the next five years that will essentially freeze all discretionary spending at 1993 levels. The caps have led the Administration to scale back NASA's budget even further.

Future budget requirements are easier to scale down than the programs that underlie them. The expectations represented by NASA's plans in the 1980s may be equally difficult to deflate.

Table 4.
Five-Year Budgets in the 1993 and 1994 Plans of the National Aeronautics and Space Administration (In billions of dollars of budget authority)

Plan	1994	1995	1996	1997	1998
1993	17.0	18.6	19.5	20.3	21.0
1994	15.3	15.7	16.1	16.5	16.8
Difference	1.7	2.9	3.4	3.8	4.2

SOURCE: Congressional Budget Office based on data from the National Aeronautics and Space Administration.

17. Testimony of Neal P. Curtain, Director of Planning and Reporting, National Security and International Affairs Division, General Accounting Office, before the Subcommittee on Science, Technology, and Space, Senate Committee on Commerce, Science, and Transportation, March 17, 1992, pp. 1-3.

18. National Aeronautics and Space Administration, *Report of the Advisory Committee on the Future of the U.S. Space Program* (December 1990), pp. 1-9.